(12) UK Patent Application (19) GB (11) 2 363 350 (13) A

(43) Date of A Publication 19.12.2001

(21) Application No 0108751.9

(22) Date of Filing 06.04.2001

(30) Priority Data
(31) 12104579 (32) 08.04.2000 (33) JP

(51) INT CL[7]
B24B 57/02 37/04

(52) UK CL (Edition S)
B3D DMN DUF
U1S S1421

(56) Documents Cited
EP 1095734 A1 EP 1036631 A1 EP 0887153 A2
WO 99/33612 A1 US 5816900 A US 5679063 A
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(58) Field of Search
UK CL (Edition S) B3D DMN DUF
INT CL[7] B24B 37/04 57/02
Online: PAJ, WPI

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(54) Abstract Title
Slurry feed for wafer polishing

(57) Slurry is fed onto a rotatable wafer polishing pad (2, Fig. 1) by means of a feed nozzle 4c mounted on a guide bar 11 which extends radially above the pad (2, Fig. 1). Further nozzles 4d may be mounted either on the same guide bar 11 or each on a respective guide bar. The position of each nozzle 4c and 4d may be adjustable along the length of the guide bar 11 by mounting each one on a respective block 9c and 9d. Each block 9c and 9d either is fixable to the guide bar 11 by means of a screw (12, Fig. 5) or accommodates a nut which engages a respective feed screw 14, each rotatably driven by a respective pulse motor 15a and 15b. Slurry supply lines 13 are spirally loosely wound around the guide bar 11. The amount of slurry fed to each nozzle 4c and 4d may be individually controlled, e.g. by means of pumps (7, Fig. 1A) or valves. Such arrangements enable slurry to be delivered onto the pad (2, Fig. 1) at the optimum positions and in the required amounts.

Fig. 6

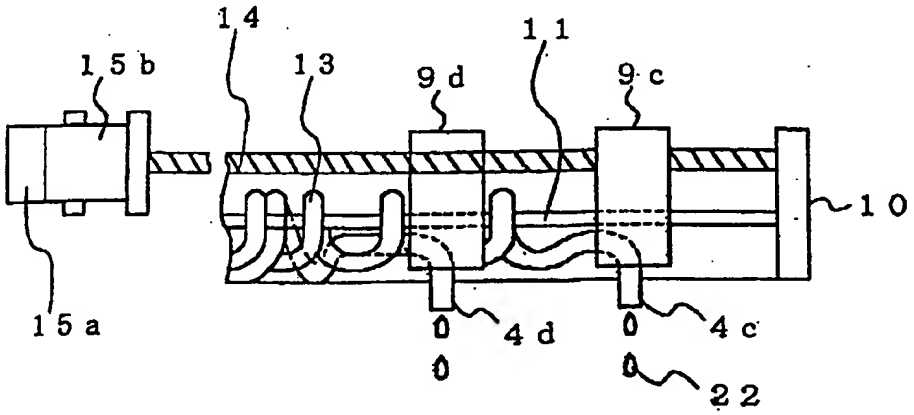

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Fig. 1A

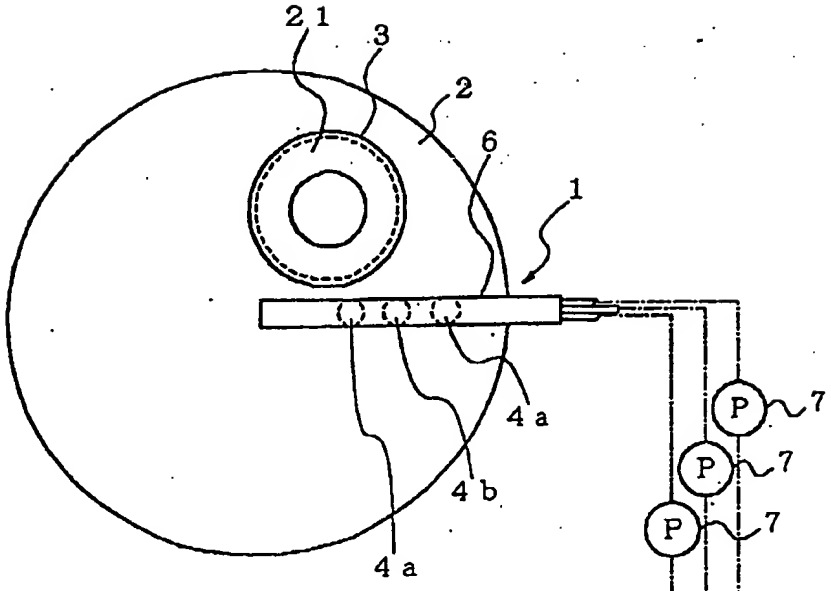


Fig. 1B

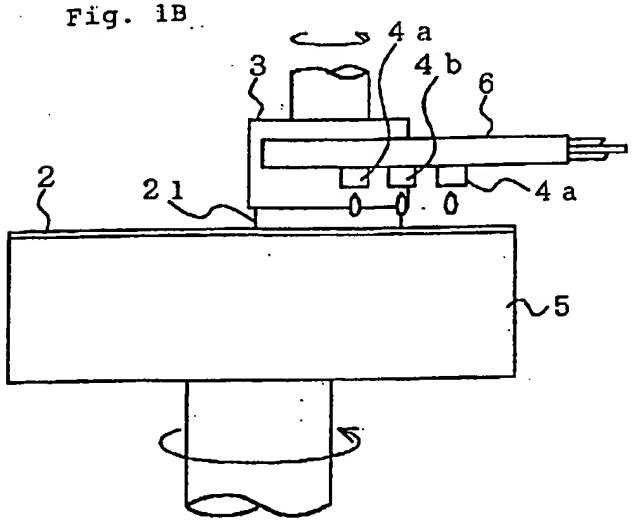


Fig. 2

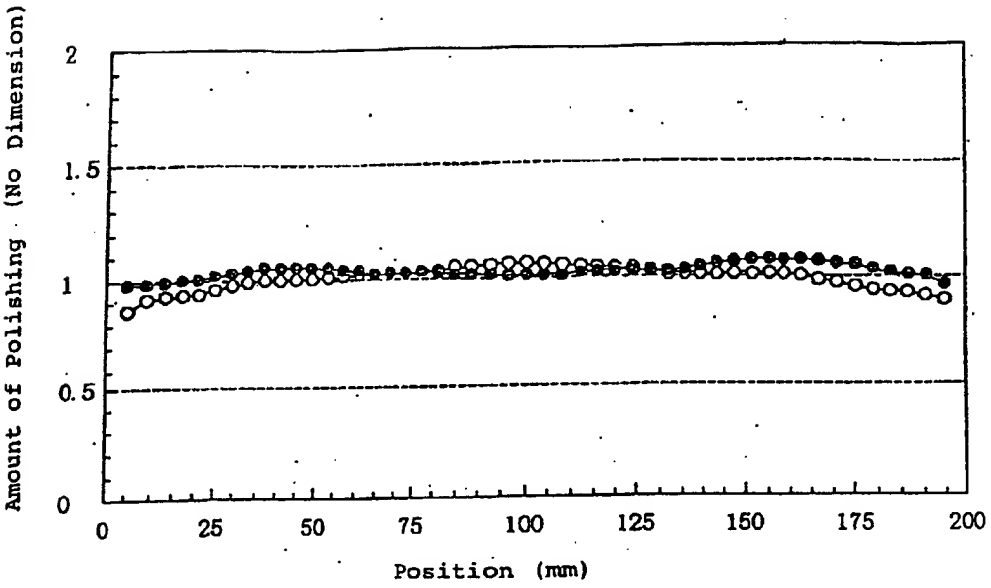

Amount of Polishing (No Dimension)
2
1.5
1
0.5
0
0
25
50
75
100
125
150
175
200
Position (mm)

Fig. 3

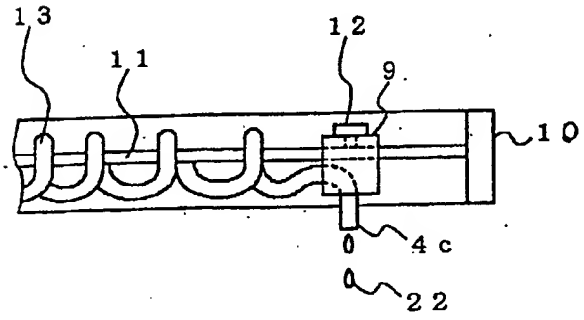

13
11
12
9
10
0
4c
22

Fig. 4

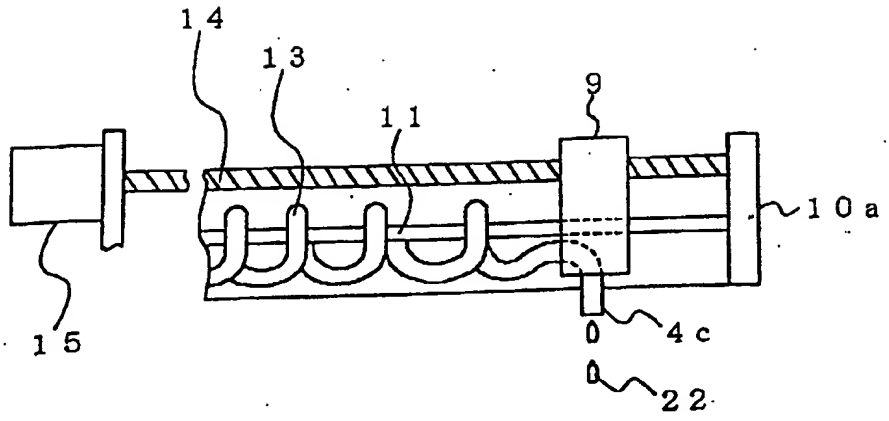


Fig. 5

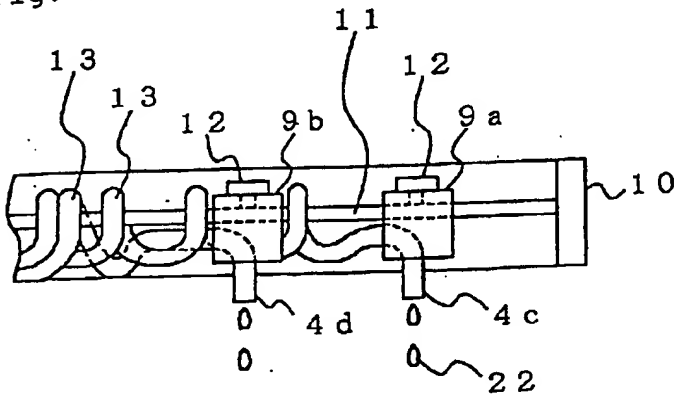
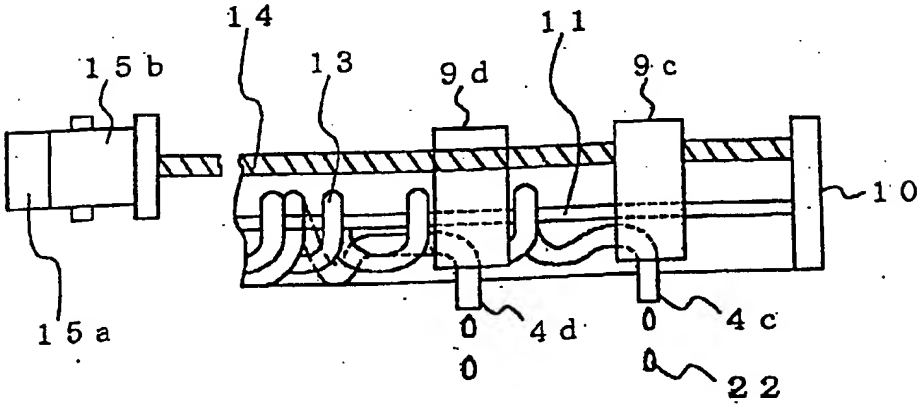


Fig. 6



POLISHING APPARATUS AND METHOD

BACKGROUND OF THE INVENTION

1. Field of the Invention:

The present invention relates generally to a method of polishing a semiconductor wafer to flatten the surface thereof and to an apparatus for carrying out the polishing method.

2. Description of the Related Art:

Processes for manufacturing an integrated circuit substrate of a semiconductor device typically include a process for flattening an inter layer insulating film, a wiring film and the like. In the flattening process, a particular technique generally referred to as a chemical mechanical polishing (CMP) is adopted.

With a reduction in the design rule of semiconductor integrated circuits, respective circuit patterns must be minute, so that each kind of aligners is required to have a high resolution. However, an increase in the resolution of the aligner causes the depth of focus thereof to be made smaller. For this reason, in order to transfer the circuit patterns onto a semiconductor wafer at a high resolution, the surface of the semiconductor wafer

needs to be finely flat to have no irregularity thereon.

Polishing of the semiconductor wafer according to the CMP is performed in the following manner. First, a polishing pad made of polyurethane foam is affixed to a rigid polishing platen, and a semiconductor wafer to be polished is held in position with a holding head. Then, the semiconductor wafer is pressed against the polishing pad and is rotated in one direction. At this stage, polishing slurry is supplied from a slurry-supply nozzle in a dropping manner to the surface of the polishing pad to polish the surface of the semiconductor wafer.

However, with this method, although the polishing slurry is supplied from one single slurry-supply nozzle to be dropped onto a radially central region of the polishing pad, the slurry cannot be spread over the entire surface of the semiconductor, so that the surface of the semiconductor cannot be uniformly and evenly polished. Further, in order to uniformly spread the polishing slurry over the entire surface of the semiconductor, an excessive amount of polishing slurry may be supplied. This, however, results in the increased consumption of the polishing slurry which is undesirable in terms of cost.

One typical polishing apparatus to solve the

problem is disclosed in Japanese Patent Laid-open No.70465/99. The polishing apparatus is provided with a spray means having a plurality of openings, which are arranged side by side in a radial direction of a polishing pad. The polishing slurry in the condition of spray or splash is blown against the radially entire portion of the polishing pad through the plurality of openings of the spray means, so that the polishing slurry comes into and is then squeezed out of finely small holes in the polishing pad. The semiconductor wafer is then polished at a reduced speed to obtain a uniformly polished surface of the semiconductor wafer.

In the aforementioned polishing apparatus, although the polishing slurry may be uniformly and evenly supplied to the surface of the polishing pad, the time of contact of a radially central region of the semiconductor wafer with the polishing pad is different from that of a radially outermost region of the semiconductor wafer with the polishing pad. Accordingly, a problem is encountered with the known polishing apparatus that even if the polishing slurry is evenly supplied to the semiconductor wafer, it is difficult to obtain a uniform amount of polishing over the entire surface of the semiconductor wafer.

SUMMARY OF THE INVENTION

Therefore, it is an object of at least the preferred embodiment of the present invention to provide a method of and an apparatus for uniformly polishing inside the surface of a semiconductor wafer with reduced consumption of polishing slurry.

Accordingly an apparatus for polishing a semiconductor wafer, according to the present invention comprises at least one slurry- supply mechanism for supplying a controlled amount of polishing slurry to both an intermediate position located between an outer end region and a central region of a semiconductor wafer, and the central region per se.

Arranging one or more slurry—nozzles in a radial direction of a polishing pad, and control of an amount of polishing slurry supplied to the polishing pad that confronts the surface of the semiconductor wafer permit a uniform polishing of the inside of the surface of the wafer. Thus, a pattern or patterns can be transferred to the polished semiconductor wafer with a high resolution.

Furthermore, since there is no necessity of supplying an excess amount of polishing slurry with a fixedly arranged single slurry nozzle, and since polishing of the surface of the semiconductor is

conducted according to the position and the number of the slurry nozzles as well as control of an amount of flow of polishing slurry, waste of the polishing slurry can be prevented, thereby reducing the manufacturing cost of the semiconductor wafer.

According to one embodiment of the present invention, the slurry-supply mechanism comprises a pair of first slurry-supply nozzles arranged side by side in a radial direction of the polishing pad and confronting the intermediate position between the outer end region and the central region of the semiconductor wafer, a second slurry-supply nozzle arranged between the pair of first slurry-supply nozzles and confronting the central region of the semiconductor wafer, and a flow amount varying means for independently supplying the controlled amount of polishing slurry to the pair of first slurry-supply nozzles and the second slurry-supply nozzle.

BRIEF DESCRIPTION OF THE DRAWINGS

Preferred features of the present invention will now be described, by way of example only, with reference to the accompanying drawings, in which:-

Fig. 1A is a top plan view of a polishing

apparatus for a semiconductor wafer according to an embodiment of the present invention;

Fig. 1B is a side view of the apparatus of Fig. 1A;

Fig. 2 is a graph illustrating a relationship between a position in a semiconductor wafer surface and an amount of polish obtained when the semiconductor is polished with the dropping amount of the polishing slurry from slurry-supply nozzles being varied;

Fig. 3 is a schematic view of a first variant of the slurry-supply mechanism shown in Fig. 1;

Fig. 4 is a schematic view illustrating another variant of the slurry-supply mechanism of Fig. 3;

Fig. 5 is a schematic view illustrating another variant of the slurry-supply mechanism of Fig. 1; and

Fig. 6 is a schematic view illustrating another variant of the slurry-supply mechanism of Fig. 5.

Description of the Preferred Embodiments

Referring now to Figs. 1A and 1B, there is shown a polishing apparatus which comprises polishing pad 2 attached to turnable platen 5, wafer holding head 3 which holds semiconductor wafer 21 and rotates in a direction shown by an arrow while pressing the wafer 21 against the surface of polishing pad 2 under a given pressure, slurry-supply mechanism 1 which

controls an amount of flow of polishing slurry to be supplied to an intermediate region between a central region and an outer end region of the wafer 21 and to the central region per se, respectively.

Slurry—supply mechanism 1 comprises a pair of slurry-supply nozzles 4a disposed side by side on sleeve pipe 6 at positions confronting the intermediate region between the central region and the outer end region of wafer 21, sleeve 6 being held above polishing pad 2 and extending in a radial direction of polishing pad 2. Slurry-supply mechanism 1 further comprises another nozzle for slurry-supply 4b between a pair of slurry nozzles 4a on sleeve pipe 6 at a position confronting the central region of wafer 21, pumps 7 for individually supplying pair of slurry-supply nozzles 4a and slurry-supply nozzle 4b with the polishing slurry, and slurry-supply sources 8 for supplying respective pumps 7 with the polishing slurry under pressure.

The amounts of the polishing slurry, i.e., the amount of flow of the polishing slurry dropped from these three nozzles 4a and 4b are determined by the numbers of rotations of respective pumps 7. Instead of controlling the number of rotations of pumps 7, flow control valves may be provided in respectives three fluid supply tubes introduced in the sleeve pipe 6.

However, since the openings of the three flow control valves may be choked or plugged with the polishing slurry it is desirable to control the flow of polishing slurry the number of rotation of the pumps 7.

Fig. 2 is a graphical representation of distribution of the polished amount of wafer surface when wafer 21 is polished while changing the amount of polishing slurry dropped from slurry nozzles 4a and 4b.

More specifically, polishing of a tungsten film of the wafer was conducted under the two different conditions. That is to say, in the first condition, the amount of polishing slurry supplied to the central region of the wafer was selected to be at the maximum as in the prior art, namely, in Figs. 1A and 1B, the amount of polishing slurry dropped from the slurry nozzle 4b was larger than that from the slurry nozzles 4a and in the second condition, the amount of polishing slurry dropped from the slurry nozzles 4a confronting the intermediate region of the wafer was selected to be larger than that from the slurry nozzle 4b confronting the central region of the wafer. As a result, as seen from Fig. 2, when a larger amount of polishing slurry is dropped onto the center of wafer (at 200 mm position in wafer surface), as indicated by a curve of white circles, a difference

between the polished amount at the central region of the wafer and that at the outer end region of the wafer is appreciably larger. On the other hand, when a larger amount of polishing slurry is dropped onto the intermediate region of the wafer between the central and outer end regions of the wafer, as indicated by a curve of black circles, a difference between the polished amounts at the two regions of wafer is rather small.

It is to be noted that the amount of polishing shown in Fig. 2 is an indication on a display, which was obtained, through conversion by a personal computer, from a thickness of the polished tungsten film of wafer measured by the four-terminal resistance measuring method that measures series resistances at respective portions of the wafer. This method is very simple and can be used to conduct evaluations as set forth below by monitoring the display indication.

Fig. 3 illustrates a first variant of the slurry-supply mechanism. The slurry-supply mechanism of this variant is constructed by taking into consideration the fact that when, for example, the quality of film of a wafer is easy to be polished or a pattern density transferred onto a wafer is low, a single slurry nozzle is sufficient for achieving the

desired polishing of the wafer. As shown in Fig. 3, single slurry nozzle 4c is attached to block 9, which is guided by guide bar 11, such that the slurry nozzle can be fixedly positioned at any position in a radial direction of polishing pad 2. Flexible tube 13 connected to nozzle 4c via block 9 is spirally loosely wound around guide bar 11 held by bracket 10 so that block 9 is allowed to move in the radial direction along guide bar 11. Upon conducting polishing operation, slurry nozzle 4c is adequately positioned to obtain a uniform finish of polishing, and subsequently block 9 is fixed to guide bar 11 with screw 12. When the polishing operation is started, polishing slurry 22 is dropped onto the surface of polishing pad 2.

Fig. 4 is another variant of the slurry-supply mechanism shown in Fig. 3. As shown in Fig. 4, the slurry-supply mechanism of this variant includes a shifting and positioning mechanism having a block 9 mounting thereon nozzle 4c and accommodating therein a nut, for permitting slurry nozzle 4c to change its position in the radial direction of polishing pad 2 even during polishing operation, a feed screw 14 being in engagement with the nut of block 9, and pulse motor 15 for rotating the feed screw 14.

Fig. 5 illustrates a second variant of the

slurry-supply mechanism. As shown in Fig. 5, the slurry-supply mechanism of this variant has two slurry nozzles 4c and 4d, which are able to appropriately and arbitrarily change their respective positions on guide bar 11. Block 9a on which slurry nozzle 4c is mounted and block 9b on which slurry nozzle 4d is mounted are able to slide on common guide bar 11, and are fixed thereto with lock screws
12.

Fig. 6 illustrates a variant of the slurry-supply mechanism of Fig. 5. As shown in Fig. 6, the slurry-supply mechanism of this variant has two slurry nozzles 4c and 4d, which are positioned at any position on guide bar 11 during the polishing operation. The slurry-supply mechanism of this variant includes a shifting and positioning mechanism having block 9c mounting thereon slurry nozzle 4c and accommodating therein a nut, block 9d mounting thereon slurry nozzle 4d and accommodating therein a nut, two feed screws 14 being in engagement with the two nuts, respectively, and pulse motors 15a and 15b which are able to independently drive the rotational motion of respective feed screws 14.

Further, the slurry-supply mechanism of this variant can always polish inside a wafer surface uniformly by adequately combining a positioning

program of two slurry nozzles 4c and 4d with a pumping out program of a slurry pump, with respect to a variety of polishing modes.

In this variant, the guide bar may be provided for each block.

Although the foregoing description has been made with reference to preferred embodiments having a single wafer holding head and a single slurry-supply mechanism, it should be appreciated that the present invention is applicable to an embodiment in which two or more wafer holding mechanisms and two or more slurry-supply mechanisms are provided.

While the present invention has been described in its preferred embodiments, it is to be understood that the words which have been used are words of description rather than limitation and that changes may be made to the invention without departing from its scope as defined by the appended claims.

Each feature disclosed in this specification (which term includes the claims) and/or shown in the drawings may be incorporated in the invention independently of other disclosed and/or illustrated features.

The text of the abstract filed herewith is repeated here as part of the specification.
An apparatus is disclosed wherein polishing slurry is supplied to a polishing pad affixed to a polishing platen to thereby polish semiconductor

wafers. This apparatus is provided with at least one slurry-supply mechanism for supplying a controlled amount of polishing slurry to an intermediate region between outer end and central regions of a semiconductor wafer and to the central region per se. Control is made such that the amount of flow of polishing slurry supplied to the intermediate region of the semiconductor wafer is larger than that supplied to the central region thereof.

CLAIMS:

1. A method of polishing a semiconductor wafer, comprising

holding the semiconductor wafer in contact with a polishing surface of a rotatably mounted platen;

rotating the platen so that the semiconductor wafer sweeps over a region of the polishing surface defining a polishing region; and

supplying polishing slurry to the polishing surface in such a manner that the amount of polishing slurry supplied to a portion radially intermediate between radially inner and outer portions of the polishing region is larger than that supplied to the radially central and/or radially outer portions of the polishing region.

2. Apparatus for polishing a semiconductor wafer, comprising

a rotatably mounted platen having a polishing surface;

means for holding a semiconductor wafer in contact with the polishing surface so that the semiconductor wafer is arranged to sweep over a region of the polishing surface defining a polishing region; and

means arranged to supply polishing slurry to the polishing surface in such a manner that the amount of polishing slurry supplied to a portion

radially intermediate between radially inner and outer portions of the polishing region is larger than that supplied to the radially central and/or radially outer portions of the polishing region.

3. Apparatus according to Claim 2, wherein the polishing slurry supply means comprises a plurality of supply nozzles.

4. Apparatus according to Claim 2, wherein the polishing slurry supply means comprises one axially moveable supply nozzle.

5. A method of polishing a semiconductor wafer, comprising the steps of:

pressing said semiconductor wafer against a surface of a polishing pad affixed to a polishing platen that is rotating in one direction; and

supplying polishing slurry to the surface of said polishing pad in such a manner that the amount of polishing slurry supplied to an intermediate region between central and outer end regions of said semiconductor wafer is larger than that supplied to said central region.

6. An apparatus for polishing a semiconductor wafer, comprising:

a polishing pad affixed to a polishing platen that rotatates in one direction;

at least one wafer holding head for holding a semiconductor wafer and for pressing said semiconductor wafer against a surface of said polishing pad while rotating in one direction; and

at least one slurry-supply mechanism for supplying polishing slurry to an intermediate region between outer end and central regions of said semiconductor wafer and said central region, respectively, while controlling the amount of flow of said polishing slurry in such a manner that the amount of flow of polishing slurry supplied to the former is larger than that supplied to the latter.

7. The apparatus according to claim 6, wherein said slurry-supply mechanism comprises:

a pair of first slurry-supply nozzles disposed side by side in a direction corresponding to a radial direction of said polishing pad and confronting said intermediate regions between the outer end and central regions of said semiconductor wafer;

a second slurry-supply nozzle disposed between first slurry supply nozzles and confronting said central region of said semiconductor wafer; and

a flow amount varying means for independently supplying the controlled amount of polishing slurry to said pair of first slurry-supply nozzles and said second slurry-supply nozzle.

8. The apparatus according to claim 7, wherein said flow amount varying means comprises a pump.

9. The apparatus according to claim 6, wherein said slurry-supply mechanism comprises:

a guide bar extending in a radial direction of said polishing pad;

one or more blocks movably disposed on said guide bar; and

one or more slurry-supply nozzles each mounted on an associated block;

each block being supported by said guide bar.

10. The apparatus according to claim 6, wherein said slurry-supply mechanism comprises:

a block having mounted thereon a slurry-supply nozzle and accommodating therein a nut;

a feed screw in engagement with said nut and mounted on a bracket; and

a pulse motor for rotationally driving said feed screw.

11. The apparatus according to claim 6, wherein said slurry-supply mechanism comprises:

one or more guide bars each extending in a radial direction of said polishing pad;

one or more blocks guided by an associated guide bar and accommodating therein a nut;

one or more feed screws each being in engagement with the nut of an associated block;

one or more slurry nozzles each mounted on an associated block; and

one or more pulse motors each rotationally driving an associated feed screw.

12. A method or apparatus, substantially as any one herein described with reference to, or as illustrated in Figures 1 to 3, or 1,2 and 4, or 1,2 and 5, or 1, 2 and 6.

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Application No: GB 0108751.9 **Examiner:** Matthew Lawson
Claims searched: 1-12 **Date of search:** 5 October 2001

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.S): B3D (DMN, DUF)

Int Cl (Ed.7): B24B 37/04, 57/02

Other: Online: PAJ, WPI

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
X,E,&	EP 1095734 A1	(EBARA) - pub. 02.05.2001 - column 9 line 8 - column 10 line 5 and figures 8-12.	1-6,9
X,P	EP 1036631 A1	(INFINEON) - pub. 20.09.2000 - paragraphs [0021]-[0024] and figure 2.	1-3,5-7
Y	EP 0887153 A2	(APPLIED) - column 3 lines 57-58 and column 7 lines 16-32.	3,4
X,&	WO 99/33612 A1	(EBARA) - see EP 1095734.	1-6,9
X	US 5816900	(NAGAHARA) - the whole specification, especially column 2 lines 33-49 & 60-67, column 3 lines 11-31 and the figures.	1-3,5-8
X	US 5679063	(KIMURA) - the whole specification, especially column 5 line 43 - column 6 line 7 and the figures.	1-8
X,Y	US 5554064	(BREIVOGEL) - figure 2B.	X:1,2,5,6 Y:3,4
X	US 5246525	(SATO) - the whole specification.	1-3,5-8

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.